NEW ENGLAND WATER WORKS ASSOCIATION.

ORGANIZED 1882.

Vol. I. June 1887. No. 4.

This Association, as a Body, is not responsible for statements or opinions of any of its members.

A RESOURCE FOR CHEAP WATER FOR THE PEOPLE.

In Massachusetts and Maine (and doubtless elsewhere)—all Ponds and Lakes exceeding ten acres in extent are legally styled "Great Ponds"—They belong to the public by a Colonial Ordnance of 1647. The land beneath them is likewise public property—no private title comes farther than low-water mark. They differ thus materially from water courses. It has recently been felt that the time has arrived for the State to devote these great reservoirs to the needs of the people viz. its towns and cities, without requiring them to pay millers who may have long enjoyed water power created by an overflow for which the State in past time has had no use. The millers on outlet streams have of course furiously resisted this doctrine and demand damages. Nevertheless the Commonwealth of Massachusetts has adopted the principle of giving this Great Pond water free to its people in several Water Works Acts—notably in one this Winter in favor of the city of New Bedford and another in favor of the town of Ayer—and in the previous session by an Act in favor of the City of Fall River.

We append a copy of one of these laws. The fullest discussion of the subject occurred however in 1886, and we print the argument then made by the advocate for the City of Fall River. We think the topic one of great practical as well as legal importance. It is too late to say longer that the rights and needs of the people shall be inferior to the claims of water power. In the state of New York—and other states—navigable rivers are held to be upon the same legal footing with the great ponds of Massachusetts.

ARGUMENT OF T. M. STETSON, Esq.

Mr. Chairman and Gentlemen of the Committee :—

The people of Fall River have submitted to you an Act which they request you to advise the Legislature to pass. It relates to future condemnations of water from the Watuppa Ponds for public use. It is based upon two propositions.

1st. That the State owns the water in these "Great Ponds" and may well give from it to its people without toll or payment.

2d. That any ancient licenses or privileges heretofore allowed by the State to parties to use, control and avail of the surplus waters after they pass into the outlet stream—the Quequechan or Fall River, shall, so far as they legally may —be revoked or prevented from standing now in the way of the proposed gift from the State to its people.

We do not ask this gift for the purpose of vending the water hereafter to be taken, but as to that formerly condemned and for which we paid about $70,000, it is supposed that we may do as we please.

As this question presents itself, I appear in form for the people of Fall River, but I do not seem to be speaking in behalf of that city alone, nor only for the 60,000 men, women and children who dwell on the shore of this splendid lake. I seem to speak for all the people of the Commonwealth, for the rights of all are similar here. The unanimous voice of the people of Fall River but typifies the unanimous call which the people all over the State will make—when their various needs become equally imperative—and when they realize that these magnificent reservoirs, the great ponds of Massachusetts, have throughout the whole of our history, Colonial, Provincial and State, been carefully and legally preserved, as the property of the State, without a single encumbrance, infringing claim or title, until their value for the needs of the people, almost the gravest physical need of humanity, has become priceless. Is it not wonderful that this public property has been kept so long and so safely? That though countless Acts of Legislature have been passed, private grants in almost every form of careless generosity, yet these glorious resources of water supply still belong to the Commonwealth, and are now ready to be given by it to its people and its children if it loves them as much as we suppose it does.

The great need of the people has now become imperative. The rivers can no longer be depended on. The lordly Merrimac brings into our boundaries the sewage of New Hampshire and its largest cities. The brooks have lost their sparkling purity, and are fast becoming conduits for foulness and filth, so that from a large part of the State the trout has substantially disappeared. Typhoid fevers and the whole class of zymotic diseases flow down the brook channels now. As the earth itself accumulates the excreta of a crowded civilization, wells must be abandoned, and fortunate indeed is the Commonwealth that to this late day has kept its title clear to those reservoirs which Nature has scattered all over Massachusetts—with a divine forecast for a coming need of the people. Is it not now, gentlemen, the opportunity for this committee to connect your names with this grand public benefit, now to initiate a procedure of the profoundest wisdom, to link your names to a declaration of fundamental right—to wit:—that the Great Ponds of the State shall be applied to the benefit of all her people without money and without price.

We are opposed in our petition by certain mill proprietors and the Watuppa Reservoir Company—every one of them a Massachusetts corporation, and who have reaped so largely from the liberality of the State in respect to these very ponds that it would seem graceful now for them to stand aside when 60,000 people want two or three millions of these gallons for important needs, out of the thirty-two millions which daily leave these

ponds—but no—they are here to oppose us. They paid nothing to the State for tolerating their uses thus far. Their little wooden dam which you will see upon your view, only cost them some $300, and yet they took out of our City Treasury $70,000, for our former condemnation of a few years since, and now they are hungry to repeat the process, Is it not time that the State interfered and revised its past good nature to them somewhat, and determined now in view of the exigences of this hour whether it loves them best or loves its people the best. Judge Hoar last Friday asked "Who is the State?" and well answered his own question thus: "It is its people," and we, the people, think we stand rather nearer the Paternal Heart of the State than these ancient mill wheels which our opponents are so anxious to convert into cash.

Our opponents pretend before you that the State has no right in these Great Ponds to give us, that our petition seeks a futile thing and that their legal rights are loftier than ours and the Commonwealth's too. Then we ask why do you come here so expensively to oppose and hinder a "futile thing"? If the State can give us nothing; has nothing to give; does not own these Great Pond waters; why are you here in such force? why this array of interested Directors, Presidents and stockholders? why have Col. Borden, Messrs. Brayton, Devol, Weld, etc., etc., brought their anxious faces and persistent resistance to this hearing? why have you engaged expensive counsel to obstruct us day after day—for certainly no counsel in the State have a better right to be expensive than my distinguished friend, Judge Hoar—and my brother Morton? It is too thin, gentlemen; Judge Hoar himself wanted to palliate this obvious thinness, and so told you that his clients feared a costly litigation of many years, extending even to Washington and the Supreme Court of the Federal Union. But this was thinner yet. These cases never could go to Washington.

Did you ever, Mr. Chairman, in your long practice know of water works cases like these going to a Federal Court? Every party is a Massachusetts corporation, and no Federal question is or can be involved. No, gentlemen; this litigation must begin and end at home. They say they fear the cost! The last litigation reported in 134 Mass. took $60,000 out of the city treasury. And did you ever know plaintiffs to "scare worth a cent" at such litigation? Besides, Washington would be the last place they would want to take their cases to. That Court has already, in three causes, decided directly against the principle they assert of the irrevocability of their license of 1826, and you will never find them wishing to set that proposition before the Supreme Court of the United States.

Our opponents assert that the State does not own its Great Pond and their waters. Let us see what the law books assert about this. Where shall we begin? An ancient author—if it was not Valerius Maximus, I know you will correct me, Mr. Chairman—says that a woman unjustly condemned by Philip the King, appealed to Philip sober. It would be discourteous to use that word here and I do not adopt it, but it suggests something. You know, gentlemen, that a member even of my profession, when paid by a client, for a purpose, employed to contend for his claims and to argue for him, does not always announce the law quite so safely and soundly as he would do if holding the commission of the Common-

wealth and sitting upon her Judicial Bench. I propose, first therefore, to appeal from my brother Hoar *arguendo* to Mr. Justice Hoar *judicando*, and to refer to that grand fortress of popular right in these Great Pond subjects—the case of West Roxbury vs. Stoddard 7—Allen 158. He told you modestly that he had something to do with that case. Modesty has kept many a man from preferment. It shall be my office to see that my friend's modesty shall not lose him now the well-earned fame to which that cause entitles him. Do you know, gentlemen, he wrote it himself. His name stands at the head of that masterly opinion. It voices not his argument, but his judgment, and that of the whole Court of the State without a dissenting voice. It is one of those monumental opinions which place his name so high in judicial history that even he himself, under "stress of circumstances," as he calls it, cannot take it down. It is one of the milestones in that forecast of 239 years, which, ever since the Great Ordinance of 1647, preserved the heritage of the Great Ponds of Massachusetts unimpaired for her people, England never did so much for her people. Her fair Windermeres, Rydalmeres, and Ulleswaters exist for the enjoyment of her nobility and property holders. But our forefathers, with a wisdom almost inspired, as long ago as 1647, consecrated the Great Ponds of the State to the public forever, And the strong, manly terms of the opinion I am about to read reinforced and fortified the ancient decree of 1647. A man may not disclaim his debts, nor will we allow Judge Hoar to disclaim the fame and honor of such a decision. General Butler once said he could drive a horse-cart through a certain decision made, I think, by a Speaker of the House. Nobody ever could drive a horse-cart through one of Mr. Justice Hoar's decisions. His "well of English undefiled," clear, terse and trenchant, leaves no loopholes for horse-carts or for criticism.

I now assert, and no disinterested lawyer will differ from me,

THE STATE OWNS THE WATERS OF ITS GREAT PONDS.

And I read from West Roxbury vs. Stoddard—7 Allen 166.

"We think it clear that by this Ordinance (1647) it was intended to devote the great ponds to public use. We are not aware that this law has ever been altered. They were not henceforth to be appropriated to the use of any particular person or persons but were declared to be lying in Common." * * "With the growth of the community and its progress in the arts these public reservations at first set apart with reference to certain special uses only, became capable of many others which are within the design and intent of the original appropriation. *The devotion to public use is sufficiently broad to include them all as they arise.*"

"It would seem to afford some confirmation of the opinion that the Ordinance of 1647 was designed to establish a large and important public right, that the provision concerning ponds is included in the same chapter of the Colony Laws which secures the right of free speech in courts and town meetings and the freedom of emigration and which regulates the respective rights of littoral proprietors and of the public upon the sea-shore. And the usage and practice under the Ordinance seems to have been consistent with the understanding that great ponds were public property. *There is no adjudged case in which any right in them adverse to the public has ever been recognized.*"

"The result of all the considerations of the court—upon the questions submitted may be recapitulated in these propositions.

1. Great ponds containing more than ten acres which were not before the year 1647 appropriated to private persons were by the Colony Ordinance made public to lie in Common for public use."

This case decides that nobody but the State could prevent anybody from cutting ice on Great Pond.

In 1880 the Knickerbocker Ice Company cut 1,400,000 tons, which in water means 56 horse power for a whole year on the Fall River slope.

But no one can object but the State says this decision.

In New York the bottom of the Mohawk belongs to the State, because a navigable stream. This is like a Great Pond. The State diverted the water, the Court held,

"Riparian mill owners not entitled to any damage against the State."

People vs. Land Appraisers, 33 N. Y. 465.

In a Great Pond, the owner on the one side cannot sue the opposite owner for diversion.

Fay vs. Salem, 111 Mass. 27.

Riparian owners on the stream own the uses of the water that actually succeeds in getting into the stream, but that is all.

No case holds that they have the right to insist that the water of a lake, Great Pond, marsh, swamp or water shed, must and shall come to and enter said stream.

The contrary is Law.

Broadbent vs. Ramsbottom, 11 Exch. 602.

Defendant owned a pond of six acres, the overflow of which flowed over the pond into the plaintiff's brook.

"Plaintiff's right cannot extend further than the flow into the brook itself, and to the water flowing in some defined natural channel. Before it reaches such defined channel the land owner has the right to appropriate it. He has a right to drain his pond and his marsh also."

And the editor, J. Clark Hare, says in his notes: "To give a right of action for diversion of water, it must be from a water course in the proper sense of the term; and the mere circumstance that a stream in one tract is fed by superficial percolations from another will not prevent the latter owner from using it, even to drying it up."

Chasemore vs. Richards, 7 H. & L. 359.

Wightman, J.—"Such a right as claimed would deprive a man of the right of draining his land," [or the State of Massachusetts from draining or filling its Great Pond.]

Chelmsford, J.—"The use which every owner in a running stream may claim is only of the water which *has entered into and become a part of the stream.*"

Roustrom vs. Taylor, 11 Exch. 367.

The upper owner has an unqualified right to drain his marsh, and a neighboring proprietor cannot complain of deprivation of water which would have otherwise come to his land, even if it got into a water-course in the meantime.

In Mayor vs. Commissioners of Spring Garden, 7 Barr. 348, the point is squarely met. It was in regard to the Schuylkill River, a navigable stream and hence belonging to the public. "The grant by the Legislature of an exclusive right to the water-power of a navigable stream does not give title to the corpus of the water."

"*Hence a subsequent grant to the district to erect water works to supply its inhabitants with water, is not in violation of the previous grant of the water power.*"

Berry vs. Raddin, 11 Allen, 580.

The Court says: "The grant was not of the pond, but of the water that flowed therefrom, and of the right to regulate the same by dams, for the operation of a mill on the outlet. The grant of such a right could not interfere with the use for which the waters of the pond were held, under the Colonial Ordinance, or impair the full enjoyment of it by the public. The grant was therefore one which it was competent for the town to make."

This makes the distinction plain between a claim by the plaintiff mills to water in the Great Pond, and a claim to that which actually gets into the outlet and would go to waste.

Cummings vs. Barret, 10 Cush. 187, was a general demurrer to a bill in equity to stop ice cutting in a Great Pond, and the bill averred "rights in and to the pond and waters flowing therefrom."

But even on demurrer Judge Shaw doubts whether they can have such a right, calls it a new and unsettled right, "and not fit to be tried in a Court of Equity till established by law," and says: "Such water taken from the body of the pond before it could reach the outlet, never could be water flowing from the pond."

The Great Pond is more analogous to a swamp or marsh, the percolating waters of which belong to the swamp owner until they reach a defined water course; and he may draw them off in another direction, so that they will never reach the defined water course.

Griffiths vs. Jenkins, 2 Allen, 590.

Dickinson vs. Worcester, 7 Allen, 22, and cases ante.

In short, till water gets into a defined water course, it has no relations with the riparian owners along such water course.

2 Washburn R. P. 67.

The line of demarkation of the title is at the point where the water, *de facto*, leaves the Great Pond and enters the water course. Till then it belongs to the State; afterwards to the riparian owners on the stream.

If the conductor pipes of the State House empty on a gentleman's garden to his very great advantage for cistern purposes, the moment the water reaches his property it is his. Till then the State may divert it, or retain it for its thirsty legislators and office holders.

It is absurd to argue that a Great Pond is part of a water course. Its water has no motion. It has no "course". The title to its bottom, its shores, its very water, are all different.

See remarks of Judge Endicott in 131 Mass. 223. The riparian proprietor of a brook owns to its centre. He does not own the land under a Great Pond. My brother Hoar's effort to make this immense pond of 3,000 acres of still water a "water course" was sufficiently absurd. He compared it to the great American Lakes, and that made it worse yet. According to his view the United States could not open a canal from Chicago to the Mississippi without becoming liable to every shore owner from Chicago to the Gulf of St. Lawrence. If these still water oceans

were "water courses," then every shore proprietor would own to their centres. But the contrary is the law, and it suffices to cite the passages already quoted from the case of West Roxbury vs. Stoddard.

The Law of that case has been reiterated in

(1881) Gage vs. Steinkrauss, 131 Mass. 222.

(1877) Hittinger vs. Eames, 121 Mass. 539.

Fay vs. Salem Acq. Co. 111 Mass. 27.

"Spring Pond (Gray, C. J.) was a Great Pond, the use of which for *taking water* as well as for fishing, fowling, etc., may be granted by the Legislature at its discretion."

Judge Hoar did not appreciate our views, about the original natural pond as it was and would be without dams, as it is at the low water dry summer time. Fifteen feet deep, says the engineer Rotch,—with its billions of gallons that never would flow out at all to a mill wheel? Whose is that? Who *reserved* that? Who put it there?

And yet during all the dry months these *dogs in the manger* say the people shan't have it, without paying them, when they can't get it themselves.

You have heard evidence showing how low the North Pond gets, having often no current out; bushes grow across there; not water enough to turn a one-horse power wheel passes.

And yet, forsooth, the people shan't have it, because Judge Hoar claims a "right of *support*." How supporting this fine drawn theorizing to the poor woman who can't wash her babies, or drink what ought to be as free as air!

How *supporting* to the hard worked stoker in this very Iron Works who comes home grimed and crusted with coal dust, and there lie 3,000 acres of water that can't flow to a mill wheel and yet forsooth he can't have it because Judge Hoar says by and by a rain storm may come which will raise it and start some mill wheel, and so we must go without for months, when one single rain storm over that water shed of thirty square miles would yield more water than all our domestic purposes would use in a month.

Why, in one rain storm 508,000,000 gallons rolled to waste over their dam —this is equal to of all the city uses in a year. Did you ever hear such greediness? Why, after enjoying without paying for it the splendid liberality of Massachusetts for many years, they grudge the State the poor privilege of giving its suffering people two or three millions out of the thirty-two millions which go down that stream daily—and grudge it too when the pond is so low that the mills would not get any of it any way. No dog in any manger ever equalled this. My brother Hoar told you a story about the military hero Caleb Cushing marching with his army in the bed of a Mexican River. He was fortunate that these, our opponents, were not located on that river. They would have charged toll against Caleb and every man in his army for walking upon its bed.

Again, Judge Hoar don't understand how a pond can "supply" what don't flow out. I can. I have actually seen wells that did not flow out.

Many ponds are great spring holes. Quittacus in Middleboro is one. Black Pond in Scituate is another. Countless ponds in Cape Cod and Plymouth have no inlet or outlet. Walden Pond in Concord has neither.

These rise so far and no farther, whether used and drawn from or not. Their remote sources can raise them to a certain mark, no more, but can hold the waters there. The North Watuppa Pond is of this character. No witness ever saw the current flowing northward into it, no matter how much the city pumps from it. Probably our use would never really affect the mill-powers on the outlet stream at all.

The rights of the Commonwealth in Great Ponds have not been discussed much in the reported water works cases because the water works Acts have generally been drafted in the interest of mill-owners, as this one of 1871 was, and provided in terms for payment of damages to them. And so in 134 Mass. 269, the Court could easily dodge this question, and rightly did so, saying they so dodged because this particular Act clearly required payment. We regard this as a friendly hint that if we come to the Legislature and get that difficulty removed we can then appear in court in better shape.

The Woburn (Horn Pond) cases are all explained in the same way. The Committee will, however, note that the Court has never hinted or suggested that the State has not, if it chooses, the full title to every drop of water in the Great Ponds.

II. In asking for a Section of the Act revoking any licenses or privileges that may have been given by the State to Mill Owners on such outlet stream to use, etc., we do not ask the Committee to determine any judicial questions of title, but only ask for a revocation so far as legally may be to be settled by the courts as individual cases arise.

Nor do we even ask for a revocation, except so far as may conflict with the free privileges we ask of the State; that is, to about three millions out of the thirty-two million gallons.

Hence, no full discussion of the State power is now needed. We wish only to show that the State has probably rights which a due care for its people now call on it to resume in favor of its people.

This is of importance, as it calls for a construction of a privilege, which, the Reservoir Co. asserts, has forever diminished the sovereignty and property of the Commonwealth; and secondly, because of the imperative needs of the public that its Great Ponds shall in the future be devoted to the calls of health, cleanliness and domestic uses, rather than to the wasteful purposes of mill power.

This Act of 1826 has varying force, according to the rule of construction applied to it.

It may be deemed a mere permission, a license, revocable at will.

It may consist with a power in the grantor to grant other licenses.

It may be only a permission to the Reservoir Co. to build a dam and get what benefit that may yield, subject to any and all other uses the State may choose to make of the pond waters, and this alone might be a valuable privilege.

Is there anything in the terms of this Act of 1826 which says the license shall continue forever? No.

Does it say that the license shall be an exclusive one, so that the State shall be disabled from giving waters to anybody else? No.

When you let a boy go into your orchard does that mean that you shall never let anybody else go too, and that you forever disable yourself, your children and your wife from going too? Certainly not.

Is there anything in this license of 1826 that purports more than a permission at will of the grantor—the State? No.

What, then, is the exact scope and limit of this Act of 1826?

Its ambiguities must be construed according to the Rule of Construction of Public Grants, and this differs completely from the rule construing private grants.

And we submit every doubt must here be solved against the Reservoir Company.

And that the Act is to be deemed only a permission, a license, not exclusive and not ousting the State of its right to revoke; to change or grant elsewhere.

It is not to be deemed a title good forever against the State?

And construed as we hold, this privilege given *ex gratia* becomes not inconsistent with the imperative needs of the public as they arise.

The cases construing such charters are numerous and of the highest authority.

About the time of the Dartmouth College case there was a tendency in some courts to regard any charter as a contract and unchangeable. It was soon, however, apparent that most of them were permissions, licenses to operate certain franchises until otherwise ordered, etc., not exclusive in their nature, and consistent with a power of revocation in the State, at the call of public convenience. They were generally written by the grantees, and were without consideration; in fact, were liberalities.

The Charles River Bridge Co. sought to make out that its charter excluded other competing structures, and the Massachusetts Court was equally divided, Morton and Wilde JJ. for the strict construction; Parker and Putnam JJ. for the free construction. The case went to the Supreme Court at Washington. Judgments in both courts were against the Charles River Bridge Co.

7 Pick. 458–469.

Other cases followed, and the rule of construction is now settled that every doubt or ambiguity is to be construed against the charter or license; that only express words, or perhaps an absolutely necessary implication, can make a charter of privilege into an exclusive grant, or prevent the State from making conflicting grants to others, and without provision for compensation. In brief, that such charters shall be mere permissive, revocable licenses, unless otherwise expressed.

Shaw, J. C.—One who claims a franchise or exclnsive privilege, in derogation of the rights of the public, must prove his title by a grant clearly and definitely expressed, and cannot enlarge it by doubtful provisions or mere probable inferences. In all grants of franchises the words are to be taken most strongly against the grantee. The expressions are his.

Cleveland vs. Norton, 6 Cush. 383.

Later, the topic was discussed in case of Commissioner of Fisheries vs. Holyoke Dam, 104 Mass. 449-457.

One after the other the decisions develop the numerous public rights which cannot be deemed granted away by a charter unless so stated absolutely.

E. g., The rights of human beings for domestic uses, extinguishment of fires, etc., were even more weighty than that of fish. The right of navigation over granted flats. The right to establish Harbor Commissioner lines. The right of boating and taking ice, etc.

To what intolerable lengths the plaintiff's claims must extend if held an exclusive grant, or an irrevocable permission as against the State! Without one dollar of consideration, the liberality of the State has allowed this franchise to operate for fifty years, a privilege of very great value even in the most limited construction, even if held a mere license. And now when the public interests demand its appropriation to a higher use, if exclusiveness can be predicated of this charter, the State cannot without compensation drain the flats of this lake, or make a highway, a causeway, or a railway in it. Population may swarm in the narrow slip between the sea and the lake, and the State cannot without pay fill up this back bay of Bristol County, and it must remain forever condemned to mere mill uses.

Proprietors Locks and Canals vs. Lowell, 7 Gray 223.
Springfield vs. Conn. R. R. Co., 4 Cush. 72.

The same same reasoning was applied to the Mill Act in Stoughton vs. Baker, 4 Mass. 538, where it was held that the Mill Act must not be so operated as to trench upon a public right [the passage of fish].

The course of judicial authority has gradually worked out the rule, that an excision of a part of the sovereignty of a State shall not be by inference or in terms in the least ambiguous, but only by express words.

In this charter there is nothing which imports exclusive privilege, or a promise that competition shall not be, or that the State will not, without compensation, by and by give the waters to another's use.

Nothing can be inferred except a license to erect a dam and get what benefits that may give them in connection with all other purposes the State may enact.

So far as the conflicting interests of its owns *cestuis que trust* are concerned, the Reservoir Co. may administer the reserves, but nothing insures that there shall be reserves.

The State does not promise to abstain from using the water in its own Great Pond otherwise, any more than it promises rain. The Reservoir Co. has its permissive license, and so far as that helps them, well and good. If in the progress of events and legislation it ceases to help them, be it so.

But it is enough to say that such a charter, by the decisions, gives no exclusive right, excludes no competition of any style, and is, in fact, only a license. Like a patent license, it is a franchise that may and must consist with others.

As well might the grantee of a letter of marque claim that no others should be issued.

It is, in one sense, a property, but so is insurance scrip, liable to be cancelled, revoked.

Susquehanna Canal Co. vs. Wright, 9 W. & S. 9.

Gibson, C. J.—"A surrender of any part of this highway, the Susquehanna, would be an act of political suicide, and we are to inquire whether the State intended to pay Mr. Wright gratuitously for his dam, and without regard to the solidity of his claim. To impute to the Legislature such an intent, would be to impute to them a purpose to squander the property of the public. The Act authorized him to lead off and use part of the water; and he is to be compensated for any "rights, privileges and property" now affected; and as it was uncertain whether he had not a valid claim, an immediate tribunal was provided to try the right and compensate a loss, if any such there were, which neither the State nor a grantee of its power could compel him to bear.

"The license was granted at his solicitation, for his private benefits. He was bound to know the State had power to revoke its license; and in this respect a grant by a public agent of limited powers, and bound not to throw away the interests confided to it, is different from a grant by an individual.

"It is not to be presumed, therefore, that in the absence of an explicit declaration it was not intended to impose on the company standing in place of the State, a burden which the State itself was not bound to bear."

New York & Erie R. R. vs. Young, 33 Penn, 175.

A miller on the Susquehanna, a navigable stream, was injured by the railroad location above. Held that the right to erect a mill-dam in a navigable stream given by Statute, must be construed to be a license merely, and revocable by the State whenever the public interests shall require it, and *that the railroad charter constituted such a revocation upon the location being made.*

Thompson, J.—"It is held by this court that the grantees of such a (railroad) franchise have the same power that existed in the State, and are subject only to the same liability, and in respect of damages *none are recoverable from the railroads, unless recoverable from the Commonwealth itself.* The right of the plaintiff to build the dam in the river was under the Mill Act. This is but a license revocable by the State, and he who accepts such license knows that he is dealing with an agent bound not to impair the public right, does so at his own risk, and a voluntary expenditure on the footing of it gives him no claim for compensation. The revocation was but a realization of the contingency on which the license was granted.'

Fertilizer Co. vs. Hyde Park, 97 U. S. 666.

"Every reasonable doubt is to be solved adversely to the corporation. (State's grantee.) Nothing is given except in unmistakable terms, or by implication equally clear. The affirmative must be shown. Silence is negation and doubt is fatal to the claim. This doctrine is vital to the public welfare."

Newton vs. Commissioners, 100 U. S. 561.

"It must not be a mere gratuity—there must be a sufficient consideration (to the State) no matter how long the alleged right has been enjoyed the State may resume it at pleasure."

11 Peters, 544, Charles River Bridge vs. Warren Bridge.

Taney, C. J.—"This charter is a bargain between a company of adventurers and the public; and the rule of construction is well settled, that any

ambiguity in the terms of the contract must operate in favor of the public, and plaintiffs can claim nothing that is not clearly given by the Act."

We find no exclusive right given in terms. There is no engagement from the State that a competitor shall not be created or improvements made that may diminish the amount of its income.

Com. vs. Erie & N. E. R. R. Co., 27 Penn. 351.

Black, C. J.—"This is the construction of a charter to a private corporation. The power claimed must be given in plain words, or by *necessary* implication. Ingenuity has here nothing to work with, since nothing can be here proved by logic or inferential reasoning. If you assert that a corporation has certain privileges, show us the words of the Legislature conferring them. Nothing else can possibly avail you. A doubtful charter does not exist, because whatever is doubtful is decisively certain against the corporation. * * * * * * * * * *

A grant by the State must be construed precisely the other way from a private grant."

If the State would want this 3500 acres drained and built upon like the Back Bay, we suppose it could take it without paying the City of Fall River; and yet our Water Works charter of 1871 has quite as much pretence for giving title and exclusiveness as the charter of the Reservoir Company.

In short, whatever State grants *may* be construed to be revocable, must not be construed to be irrevocable.

And this Rule of Construction of a State License or grant is now established in every State in the Union and in the Supreme Court of the United States.

But for the purposes of this Act petitioned for, the Committee need not actually decide upon these important propositions of Law, for we ask only that these things may be done so far as the State may legally do them. This saves to any remonstrant and other persons any rights, if any they have. *We know they have none against the State and are willing to take our risk of that.*

In fact, gentlemen, we are only asking you to adopt a policy in respect of Public Water that has already been adopted in this State in respect of Public Fisheries.

See Cole and Eastham, 133 Mass. 65.

This was a Fishery Case in 1882. The opinion is given by Mr. Justice Devens. The Town of Eastham obtained an Act similar in its compensation clause to the Fall River Water Act of 1871. The private owner of a fishery on the stream lost his property to the town. It had been his. He owned it as against everybody but the State. He thus stood as well or better than these remonstrants. He could sue trespassers for meddling with the fish, etc., etc.

The State exerted its ancient property rights under this same ordinance of 1647 and gave the fishery to the Town of Eastham, by an act which provided just as the Fall River Water Act does, for payment of all damages, to parties damaged and Mr. Cole went to law for his damages. But the Court well and justly held that he could recover nothing against the State or its grantee the Town of Eastham, that the ancient rights of the State were superior to those of Mr. Cole.

And so it is the Law that the State can give a fishery to a Town which need pay nothing to the so-called owner of the Fishery, whereas, if it gives its water to a Town for the imperative needs of the public, the public has thus far been made to pay for the water. Why is this absurd discrepancy? The Rights and Title of the State arise in both cases under the same ordinance of 1647. They are exactly the same in each case. Why, I say, is this absurd discrepancy? Is the creation of a public fishery any more lofty and exalted an Exercise of Eminent Domain than the creation of a free water supply for human beings? In my judgment the latter is an hundred fold more lofty and important an act. Are herrings and ale-wives more worthy than pure water, so essential to the Public Health, Comfort and Cleanliness? John Wesley, the great founder of Methodism, said that "Cleanliness was next to Godliness." If this be so, in what step of this high classification shall we place herrings and alewives. I do not criticise Mr. Justice Deven's opinion in *Colc vs. Eastham.* He was right, but I do say that the enjoyment of free public waters in great ponds by the public ought to be and must be placed on as high a grade and in as lofty a rank as alewives and herrings. Let it, gentlemen, be no longer possible to say that the Bay State ranks fish next to or identical with Godliness, but remands the mighty subject of the purity and comfort of its people to a lower plane and to a less parental care. It will be your pleasure, gentlemen of the Committee, to put an end to this preposterous discrepancy in things that should stand on the same legal footing. Let it be no longer said that when Fall River, New Bedford, Pittsfield, Boston, etc., etc., need waters belonging to the State that they must pay mill owners for them when Eastham can get, and rightly to, its public fishery without paying for it.

The absurdity of this discrepancy grows upon you as you think it over Why, if Fall River procured an Act to make a public fishery in this very Fall River, with the same words as to paying damages that occur in our Water Act, we could not only take every private right of fishery that exists or might exist upon the stream, but we could also open fish ways through every one of these mill dams and thus let to waste large quantities of water and should have nothing to pay to these remonstrants or anybody else.

Stoughton vs. Baker. 4 Mass. 522.

Yet such fishways would directly take from these water wheels far more water than our pump three miles off in another pond ever would.

The evidence shows that a dozen or more steam cotton mills recently built are already helping themselves out of these Great Ponds above the dam. They are doing just what the people are seeking to do, and they have not even a Water Works Act, and they have the monumental impudence to say we are hurting them, and to claim damages from us. Are we to be told gentlemen, that the boilers of cotton mills fed right out of these ponds are loved more by, and are preferred by our noble old Commonwealth to men, women and children?

I own something in cotton mills myself—more than I wish I did—but if such talk as this is to prevail in a country of Popular Rights, one may well be concerned for the Republic: for the people won't stand this. The people of Massachusetts are not Communists, Anarchists or Socialists, but they never will stand this.

"But," says my brother Hoar, "the mills have enjoyed this water for a long time." So have I long enjoyed many a privilege that belonged to another. I have enjoyed fair prospects and soft breezes over my neighbor's ground, but when he gets ready, shall he not build on his land? I have shot through his woodland, caught trout in his forest stream at his free consent, but shall he not when the time comes cut down his wood, take his stream to his own use—or give its waters, if he desires, to some suffering town? Plundering wood-choppers and tolerated squatters have long cut into the national forests, but shall not the U. S. Congress, when it pleases, exert its title either for public uses, or to give free homesteads to its citizens without paying toll? So did Mr. Cole of Eastham own his fishery till in the fullness of time it became wise that the Superior title of the Commonwealth should be exerted in favor of the Town of Eastham.

III. The time has come when the policy of the State should be to give its own Great Ponds to its people without paying toll to anybody.

The Great Consecration of 1647, 236 years ago, of these waters to the public was, says the Court in West Roxbury vs. Stoddard, ample to satisfy the unknown developments of the future. "*The devotion to public use is sufficiently broad to include them all as they arise.*" It is your function, gentlemen of the Committee, to see to it that the far-reaching wisdom and providence of the Puritans of 1647, shall now have their perfect work and fruition. Yes, our opponents said truly that everybody will come as we come: Boston will come, for the crowded myriads of its future can never be supplied with their present means. The thronged towns of Essex—the dense population of Middlesex—the compact villages rising all over the Commonwealth, will all come. We are now but speaking the voice of the innumerable multitude—of the people of Massachusetts. But the remonstrants were not correct when they called this Act the "Entering Wedge." That wedge was started and driven in 1647. It has never been withdrawn, but was driven in harder and solider by the court, in Roxbury vs. Stoddard, and by many other decisions.

Of course the ancient policy was to encourage mills, but never at the expense of the people's thirst and uncleanliness. Besides, steam now attends to the encouragement of mills, and the shrewdest calculator of all the cotton spinning remonstrants, Mr. Borden, Mr. Brayton, Mr. Weld, etc., etc., will not assert that water power now can make a yard of cloth any fraction of a cent cheaper than steam.

A little cotton mill can't prosper. Nor can a big one if it must have two plants for power; that is, the expensive outlay for steam and water both; and every one of these mills has long since outgrown its water power, and has to maintain two separate power plants. In fact about all the value left it is to use it for a claim of damages whenever the public needs the State's water.

I say the Policy and Duty of the Commonwealth now is to help the people. Who dares to talk of a State policy to let water waste over a water-wheel where the expenditure for one horse power would satisfy the domestic uses and needs of ten thousand men, women and children. The policy of the State now, in 1886, is to care for the ten thousand, and such policy is co-ordinate with Law, Justice and Humanity.

Let these splendid cisterns of the eternal hills be now devoted, yes, consecrated to their most exalted use without toll or tribute to any man or corporation. Take from no one his legal right if he has any, but give us what belongs to the State. We know the State can legally do all we ask, and will assume the burden of asserting these rights of the Commonwealth in Courts, if you gentlemen will by the act petitioned for, give us a chance to do so.

In all fairness, and in the name of all the people, gentlemen, give us a chance to try.

HOUSE . . . No. 102.

Commonwealth of Massachusetts.

HOUSE OF REPRESENTATIVES, Feb. 23, 1887.

The Committee on Water Supply, to whom was referred the petition of the city of New Bedford for a grant of the waters of Little Quittacas Pond in the town of Lakeville for the purposes of its water supply, report the accompanying Bill.

For the Committee,
JOHN M. McDONOUGH.

Commonwealth of Massachusetts.

In the Year One Thousand Eight Hundred and Eighty-seven.

AN ACT

Relating to the Water Supply of the City of New Bedford.

Be it enacted by the Senate and House of Representatives in General Court assembled, and by the authority of the same, as follows :

SECTION 1. In taking and using the waters of Little Quittacas Pond, as provided for in chapter one hundred and forty of the acts of the year eighteen hundred and seventy-eight, the city of New Bedford shall not be liable to pay any other damages than the state itself would be legally liable to pay.

SECT. 2. Said waters may be directed by said city into its storing reservoir in the town of Acushnet, or in the conduit therefrom, or to both of the same as it may be deemed, from time to time, desirable, and said city shall have power to take and hold, by purchase or otherwise, lands, and build and maintain conduits to such ends; and, also, such lands on each side of such conduits as may be deemed necessary or prudent, not exceeding two and one-half rods on either side, and may, from time to time, take and hold, by purchase or otherwise, such land or lands around the margin of said pond, not exceeding five rods in width, as may be deemed necessary for the pres-

ervation, control and purity of the waters thereof; and the method of condemning lands shall be as provided in said chapter one hundred and forty of the acts of the year eighteen hundred and seventy-eight.

SECT. 3. Any provisions of law, so far as they are inconsistent herewith, are hereby repealed.

SECT. 4. This act shall take effect upon its passage.

QUARTERLY MEETING AT BOSTON,

MARCH 9, 1887.

The March meeting of this society was held at Young's Hotel in Boston on Wednesday, March 9. About fifty members and guests had assembled and were engaged in animated conversation when, at one o'clock, dinner was announced. After cigars had been lighted, President Rogers introduced Albert F. Noyes, Mem. Am. Soc. C. E., City Engineer of Newton, Mass., who read a carefully prepared paper upon "Driven Wells as a Source of Water Supply."

Mr. Noyes began with an historical sketch in which he named when, where, and by whom the use of driven wells was begun in this country. Colonel Green and Calvin Horton are closely identified with this method of obtaining water. The paper described in considerable detail the tools and methods employed, and distinguished between driving and boring.

The great difference in the quantity of water which is stored in the voids of different soils was noted and figures were quoted. The writer insisted that the amount of water to be obtained from any system of pipe-wells can only be known with any approach to certainty after thorough experiments extending over a considerable period of time. The question as to the comparative amounts of water to be obtained from driven and open wells was briefly discussed and the conclusion reached that no general rule could be furnished

By the courtesy of Chief Engineer Van Buren, Mr. Noyes was able to give full details of the Andrews driven wells in use at Brooklyn, N. Y., which may be quoted as a successful example of this method of obtaining water.

Cohassett, Hyde Park. and Westboro, Mass., were mentioned as towns in which driven wells have been successfully used.

The paper was discussed by M. M. Tidd. Mem. Am. Soc. C. E., of Boston, who was in charge of the work at Hyde Park and who confessed to a lack of confidence in driven wells in general, but admitted that in many cases this seemed to be the only feasible method.

Mr. Tidd spoke of Cohassett, Mass., as an instance of driven wells in an unusually favorable location, and said that the evident water-shed is an important factor in selecting a location.

Mr. J. A. Tilden of Boston, who, under the direction of the late J. C. Hoadley, C. E., conducted a series of experiments in the town of Melrose, to determine if the slope of the ground-water toward a driven well were any greater than toward a dug or open well, gave some account of those experiments.

This careful and exhaustive set of experiments seemed to show that no more water can be obtained by any patented process than can be had by any simple method of driving.

President Rogers spoke of the experience of certain parties in Lawrence, Mass., who have endeavored to obtain water for boiler use from driven wells, and who have ruined their boilers thereby, while C. F. Allen, Secretary of the Hyde Park Water Company, gave evidence of a contrary character.

THE DRIVEN WELL SYSTEM AS A SOURCE OF OR A MEANS OF OBTAINING A WATER SUPPLY.

By ALBERT F. NOYES, City Engineer, Newton, Mass.

In considering the question of the value of the driven well system as a source of or a means of obtaining a water supply, one has to practically consider the whole question of ground water or subterranean supply as obtained by driven, bored, Artesian, or open wells, for the general laws governing each are substantially the same, and by various modifications they often operate together. Thus a driven well by passing through an impervious or semi-impervious stratum becomes an Artesian or flowing well, or an Artesian well may, by the driving of other wells, cease to flow, and then be called open or driven. The definition of a driven well is commonly given as one formed by driving or forcing a wrought iron or galvanized iron tube down into the stratum from which the water is to be taken. These pipes are generally from 1½ inches to 8 inches diameter, and may or may not be furnished at the lower end with a wrought iron or steel point. Above this point, the pipes are perforated for some distance with holes to admit the water.

*"It is claimed that Nelson W. Greene, a colonel of New York volunteers in the late war, to give the men of his command pure water, devised in his own mind a method by which this could be done, and a test was successfully made in 1861 on the fair ground at Courtland, N. Y., at the expense of one Graham, who had a contract to supply food and other necessary articles to the soldiers in camp there.

"This well was used generally by the men in camp and by Graham and his employees. In 1868, Greene procured a patent for this invention, and in 1871 had a re-issue thereof, in which he claimed as his invention the creation of a vacuum in the lining of the well for the purpose of using the pressure of the atmosphere to bring up the water."

The claim was also made and allowed for the construction of a tube well without the removal of the material.

The issuing of this patent has been the source of a large number of law suits, and the payment of large sums of money as royalty by individuals and corporations when the sum at stake would not warrant a suit.

In the suit Andrew vs. Hovey, brought in the United States Circuit Court for the Northern District of Iowa, it was shown that in 1851, in

*Engineering News, Vol. 10.

Independence, Mo., a tube was driven in the water-bearing stratum, and by a pump attached to the tube, water was drawn through it, apparently in inexhaustible quantity.

It was further shown that in 1849 and 1850, E. W. Purdy, a well-maker in Milwaukee, Wis., drove a number of these wells, some of them to the depth of sixty to one hundred feet. Another case in our own neighborhood has come to my notice, wherein driven wells of this character were in use previous to its inception by Col. Greene, the details of which may be of interest to the Association.

Calvin Horton, of East Somerville, Mass., was employed in 1851 in putting in deep well pumps. His attention was called to an open well which had become filled up with sand and yet a free flow of water could be raised with the pump, about the end of the suction of which a metallic gauze had been wound. This led to the question of the necessity of constructing open wells. In order to test its practicability, he claimed that in June, 1859, he drove a wrought iron pipe one and one-half inches in diameter, with one end perforated with small holes for a distance of about two feet. In order more readily to drive this in, and to protect the perforations from injury in the passage of the pipe through the ground, he had a wrought iron point and sleeve made, extending from the end of the pipe to a point above the perforations. The pipe was driven by inserting an iron drive rod inside of the pipe and resting on the bottom of the sleeve or point. The pipe was driven through twenty-eight feet of clay into a stratum of sand and sea-washed gravel, making a total length of thirty-six feet. The point and sleeve was then driven ahead of, or away from the pipe. Upon attaching a pump to the pipe and cleaning the end of the pipe from fine sand which had washed in, he obtained a free flowing well, yielding, at a point three feet above the surface of the ground, eighty-five barrels of water in twenty-four hours. The water rose in the pipe to the height of seven feet above the ground. Early in the year of 1861, he claims to have put in his first driven well for which he received compensation. It was put in for Charles Linehan, of Cambridge, and was located on land about ten feet lower in level and three-fourths of a mile distant from the first well, and upon ground about six feet above high tide level. The tube was sixty-seven feet deep, and was driven through fifty-four feet of marsh-mud and clay and into a stratum of sand and gravel. The water flowed freely from the well, a pump was attached to it, and the water was used for domestic purposes.

It may be of interest to note here that the draft upon the second well caused the flow from the first to cease, but upon the cutting off of the pipe of the first well to a point within eighteen inches of the ground, the flow was restored.

Early in 1863, Mr. Horton put in a two inch tube well for Burr Brown at the Hingham Dye House. This well was forced through a yellow, clayey quick-sand about forty feet, and into and through about eight feet of gravel, and furnished, by constant pumping, about ten thousand gallons of water per twenty-four hours.

In 1876, the well being insufficient for the increased demand upon it, two more tubes were put down. They were ganged to or connected to the

first, and the three were connected by a 2½ inch suction pipe to a steam pump. The yield from these wells continues substantially as when first put down, and, with the exception of the first well, they are in continual use to-day.

The introduction of water for the public supply rendered the first well of but little value, and it was recently connected with the public sewer, and when last seen was flowing as at first.

During the years 1865 and 1867, he put down a number of wells for the Boston & Fitchburg Railroad; at the Brighton cattle yards a series of seven 1¼ inch tubes were put down thirty feet deep and connected. At the Union cattle yards, at Watertown, a set of nine 1½ inch tubes was driven in the gravel and sand deposit twenty-seven to thirty feet deep. These were later connected with eighteen additional 1½ inch tubes, and connected by a four inch suction pipe with a steam pump.

The Shaw patent, so-called, for ganging of driven wells was issued in April, 1870, but from the above it would seem that the scheme had been in public use some years previous.

Over 150 patents have been allowed upon various devices for well points to prevent the inflowing of the finer material into the well. As they consist for the most part in devices or ideas for attaching fine wire or perforated gauze about the perforated pipe, it seems to me they can be of but little permanent value, the space between them and the pipe soon filling up with rust, and these well points with outside covering are, so far as I can learn, the only cause of diminished yield, other than that caused by the driving of additional pipes within the area influenced by the well. Better results are usually obtained by driving an opened end pipe having attached at its lower end a steel shoe similar to a common pipe coupling. This is first forced into the ground and a small hollow rod or pipe, to which a steel point is welded, has small holes drilled into it, so that a jet of water forced into the rod will discharge into the holes and play on the point of the drill. This loosens the material about the point of the tube and a large part is forced, by overflow, out from the pipe. The wash pipe is then removed, the tube driven until checked by the resistance of the earth, when the process of cleaning out is renewed until the level from which it is desired to take the water is reached.

When a number of water-bearing strata of coarse material are encountered, additional pieces of perforated pipe may be advantageously inserted, thus materially increasing the yield and diminishing the velocity of the water flowing into the pipe at any one point, thus preventing a tendency towards an inflowing of the finer material.

Precaution should be taken, where a number of pipes are to be connected, not to place any of the perforated pipes at a level above that affected by the suction from the pump, this level limiting the depth or level from which the ground water can be drawn.

Where it is desired to determine the character of the strata through which the pipe is being driven, a sand pump may be used with better results than with the driving rod.

This is usually a metallic cylinder of a little less diameter than the inside of the bore of the well tube, having a clap valve at one end and a

handle at the other which acts as a guide to a rod to which is attached a washer closely fitting the inside of the cylinder. The rod is worked up and down, acting as a suction rod to a pump, thus filling the cylinder or pump with the material which is withdrawn. The process is continued until the well is cleaned out; after this the driving continues.

The driving of small tubes is usually effected by sledges striking upon an iron-bound wooden block, or by a small, portable pile driver, or by a weight or monkey running over a portion of the tube and striking against an iron clamp. This weight may be raised by a rope passing over a sheave or sheaves attached to a tripod, or clamped to the upper portion of the tube.

The larger tubes are driven by pile drivers with large, heavy, wooden hammers attached to a rope which passes over a sheave at the top of a high derrick and operated with steam power.

In driving, great care must be taken to keep the joints of the pipe well screwed up for the jar from driving has a constant tendency to unscrew the sections of the pipe.

A process has recently come to my attention for clearing the well tubes, known as the Wagner Steamed Well Process, and is a substitute for the water jet process. The excavation and the removal of the material is effected by the injection of a jet of steam, under a high pressure, at the end of the well tube. It is stated that all of the finer material is forced out from about the tube and that the cleansing power of the steam is greater than that by the water jet, and its influence is felt at a greater distance than by any other process. It is also claimed that excavations have shown all of the finer material to have been washed out for a distance of at least twelve feet.

In order to fully determine the relative value of the two methods of well driving, five wells have been driven at Franklin, Ohio, with a light pile driver and sand-bucketed in the usual manner, and one well by the steamed well process, and each of the wells is to be tested separately.

It might be well to consider here the source from which wells derive their supply and the natural laws governing them. It will undoubtedly be conceded by all, that the source of all water supply is primarily that derived from the clouds or atmosphere, in the shape of rain or snow, a portion of which sinks into the earth, and where the surface deposit is gravel, or other porous material, overlying some impervious stratum or rock, the water collects and constitutes the ground water of the locality. J. T. Fanning, in his treatise on water supply engineering, says, "Respecting the porosity and absorptive qualities of different earths, it may be observed that clean silicious sand, when thrown loosely together, has voids between its particles equal to nearly one-third its volume of cubical measure; that is, if a tank of one cubic yard capacity is filled with quartzoid sand, then from thirty to thirty-five per cent. of a cubic yard of water can be poured into the tank with the sand without overflowing.

"Gravel, consisting of small water-worn stones or pebbles, intermixed with grains of sand, has ordinarily twenty to twenty-five per cent. of voids.

"Marl, consisting of limestone grains, clay, and silicious sands, has from ten to twenty per cent. of voids, according to the proportions and thoroughness of admixture of its constituents.

"Pure clays have innumerable interstices, not easily measured, but capable of absorbing, after thorough drying, from eight to fifteen per cent. of an equal volume of water.

"The water contained in clays is so fully subject to laws of molecular attraction, owing to the minuteness of the individual interstices, that great pressure is required to give it appreciable flow.

"Water flows with some degree of freedom through sandstones, limestones, and chalks, according to their textures, and they are capable of absorbing from ten to twenty per cent. of their equal volumes of water.

"The primary and secondary formations, according to geological classification, as for instance, granites, serpentines, trappeans, gneisses, micaslates, and argillaceous schists, are classed as impervious rocks, as are, usually, the several strata of pure clays that have been subjected to great superincumbent weight.

"The crevices in the impervious rocks, resulting from rupture, however, gather and lead away, as natural drains, large volumes of the water of percolation.

"The free flow of the percolating water toward wells or springs, is limited and controlled, not only by the porosity of the strata which it enters, but also by their inclination, curvature and continuous extent, and by the imperviousness of the underlying stratum, or plutonic rock."

It is estimated that in a free, open soil, about one-fourth of the rainfall percolates into or is absorbed in the ground, and the balance is taken up and evaporated by vegetation, or flows off over the surface to the streams and ponds. As the laws of gravity govern the flow of water through the soil in the same way as in streams, retarded only by the frictional resistance of the material through which it passes, the more compact the material the greater head required to force itself to an outlet, hence the reason for the great difference in the level of the ground water, even in localities of small area.

In order to determine the availability of a district to furnish a supply of ground water, the topography and geological formation must be carefully studied. If taken from porous strata, underlying impervious strata, then its outcrop must be carefully traced to determine the area to be depended upon, its elevation above the points from which it is to be taken, and the amount of water and the rapidity with which it will yield its stored waters If it is to be depended upon as the only source of supply, then the storage capacity from the plane of the frictional grade of the ground water and above the level from which it is to be taken, must be equal to the maximum consumption during the months of the year when the percolation is less than the demand.

We have numerous instances of large amounts of water being thus obtained, and, as in many portions of our country the stratification is homogeneous in character with an outcrop covering large areas, the amount of water to be obtained can be closely estimated. The causes of failure are numerous and the work should only be undertaken after a careful testing of the capacity of the soil. Experimental wells should be driven and the effect continued pumping may have on the ground water carefully noted.

If, by pumping, the level of the water is quickly drawn down and continues with a uniform yield and a quick recovery of the original level upon

stopping the pumps, then it may be assumed that the storage area is small, but the supply is constant through an open strata.

If the yield should be equal to the capacity of the pipes without lowering the ground water, then may the supply be assumed to be abundant. If the level is reduced slowly and has an equally slow recovery, it would indicate thereby a storage reservoir without material supply. It is found in about all drift formations that a layer of gravel or coarse sand, variable in thickness, lies just above the bed rock. In this layer the freest flow of water can ordinarily be found.

The ground water, when first drawn to the surface, is usually of a temperature of from 48° F. to 51° F., the temperature of the ground, which approximates the mean temperature of the atmosphere for the year. If reinforced by surface water, then the temperature is raised or lowered according to the season of the year and the distance it has had to pass through the soil.

As compared with surface water, it is less liable to contamination from organic substances and can be delivered at a lower temperature in summer and a higher temperature in winter.

The tube or driven well, as compared with an open well, is usually driven to a greater depth and into various strata, and thus the water, from its slow filtration through the soil and partial oxidation, is less liable to pollution. If these strata should be more open than those in which the open well is placed, then would the friction be less, the circle of influence be enlarged, and the yield so much greater.

A series of driven wells located at such a distance apart as to draft upon the area within their limits, extends the circle of influence as far beyond that of the open well as the distance between the extreme wells is greater than the diameter of the open well; this is modified by the variableness of the strata from which each is drafting.

The driven well also has the advantage of being practicable in soil through which it would be impossible or difficult to construct an open well.

Probably the most successful plants of small tubular wells are those put in by William D. Andrews & Bros. for the city of Brooklyn, L. I., N. Y. The surface of the ground of the western portion of Long Island rises gradually from the ocean on the south to the ridge on the north. This slope has long flat lateral slopes crossing the general slope which serve as collectors of the excess of water over and above what the ground will absorb, which appears in the form of small streams and numerous ponds and swamps which serve to store the surface water. The subsoil is for the most part sand and gravel of a homegeneous character.

The source of the Brooklyn water supply is in streams, ponds, and open and driven wells. The grade of the ground water is from seven to twelve feet per mile.

The average daily consumption for the year 1886 was about forty-five millions of gallons, with a maximum consumption of fifty-eight millions of gallons. Of this, twenty millions of gallons per day was supplied during the time of severest drouth from the driven well systems. These wells are located parallel to the line of the conduit and across these small lateral

valleys before mentioned. Spring Creek and Baisley Station, so-called, were constructed in 1882, and yielded over nine millions of gallons daily for several months in 1885.

The plant consists at each of these stations of 100 two-inch pipes driven with a patent well point.

The depth of the wells varies from forty to seventy feet. The elevation of the ground is about ten feet above tide water. Experiments with test wells at Spring Creek did not show any effect upon the ground water two thousand feet away, but I am not informed as to how long the test was continued or to what level the water was drawn at the wells.

In 1884, Forest Stream and Clear Stream Stations were built. These stations averaged for eight months, in 1885, during the drouth, over 10,500,000 gallons daily. There are 240 two inch wells at these two stations. The depths and elevations of these wells are about the same as at the first stations.

I am informed that over 12,000,000 gallons per day have been pumped from these two stations, and constant pumping does not appear to have reduced the supply. Three open wells, fifty feet in diameter, which are placed in similar, or more favorable conditions to those of the driven wells, and sunk so as to have fifteen feet of water, will not yield over 1,000,000 gallons per day.

In 1875, at Long Island City, in the construction of a brick well, fifty feet in diameter, a large flow of quick-sand was encountered which threatened its destruction, but a six inch pipe, driven in the bottom about thirty feet deep, concentrated the flow of water and no change has since occurred. The well supplied 500,000 gallons per day. Three four inch pipes were driven to about the same depth as the open well pipe, and in opposite directions from it, at a maximum distance of 5,605 feet from the wells. These showed a yield of 40,000 gallons each per day in addition to that obtained from the well. These pipes were attached to the suction pipe from the well. The claim for this arrangement was that the water in the well being drawn to a lower level than the ground water acted as a syphon pipe, thus equalizing the draft.

I am informed by the engineer that the yield has increased rather than diminished. These pipes were driven with open ends and perforated with one-fourth inch holes for a distance of two feet from the end.

At East New York, a well fifteen inches in diameter and fifteen feet in depth of water yields between 200,000 and 300,000 gallons per day of twelve hours working.

A six inch pipe was driven in the centre and three outside, at even distance from the well, about fifty feet, and attached to the suction as at Long Island City. The yield was brought up to one million gallons per day of twelve hours.

At Dayton, Ohio, a series of nine six inch wells, driven forty to forty-five feet in the former bed of the Mad River, and cleared by the Wagner Steamed Well Process, gave a daily yield, in January, 1886, of 3,260,000 gallons.

At Franklin, Ohio, six wells six inches in diameter, driven sixty to seventy feet deep, through twenty-six feet of gravel, one foot of soil, ten feet of clay

and gravel, and twelve feet more or less of gravel, it is claimed yielded over 1,000,000 gallons per day.

At Texarkana, Ark., a set of ten wells was sunk about forty-five feet deep, through twelve feet of quick-sand, thirteen feet of gravel, three feet of yellow sand and hard, tough clay, and eighteen feet of coarse gravel resting on a bed of fine sand. A test of twelve days' continuous run, yielding from 625 to 825 gallons per minute, lowered the ground water five feet, the water returning to its normal height in about four hours after the completion of the test.

At Terre Haute, Ind., a set of ten eight inch wells, sunk about twenty-three feet, yielded 2,700 gallons per minute.

In our immediate neighborhood we have a number of plants which have been to a considerable degree successful, certainly more so than open wells or conduits could be expected to have been under the conditions.

At Hyde Park, Mass., in the valley of the Neponset River, at the foot of the Blue Hills, is located a plant of sixty-four two inch wells, placed so as to intercept the ground flow of the valley, and connected by eight inch and ten inch suction pipes to the pumps.

The pipes were perforated eighteen inches to two feet on the side and driven with open ends from twenty-two to forty-five feet deep.

The temperature of the water was uniformly 50° F., and 900 gallons per minute were discharged.

During a test continuing five days of ten hours pumping, the vacuum gauge at the start showed ten inches vacuum, and at the close 15½ inches, and a maximum variation of 2½ inches per day was also shown. I am informed that the extreme variation in level of the ground water 1,500 feet away was two inches.

At Cohasset, Mass., a set of sixty-five two inch wells, driven from twenty-two to forty-five feet deep through clay, sand, and gravelly sand, and connected by a suction pipe varying from four inches to ten inches in diameter to a pump, yielded, in a test lasting five days, 450,000 gallons per day. The ground water was lowered ten feet at the wells and 1½ inches 1,500 feet away.

At the State Homeopathic Insane Asylum, at Westboro, Mass, thirty-three two inch wells were sunk about fifty-five feet deep, through a clayey sand into from four to eight feet of gravel overlying bed rock, and yielded, on a two days' test of ten hours each, 450 gallons per minute. The level of the water in a test tube 150 feet from the well was lowered seven feet in ten minutes and held at this level during the continuance of the pumping, rising to its normal level five minutes after the pumps were stopped.

At Newton, Mass., near the pumping station of the Newton Water Works a set of eight wells (four, four feet and four, six feet in diameter) were driven to a depth of from thirty to forty-five feet through meadow mud, clayey quicksand, and into from two to six feet of coarse sand and gravel.

A test of continuous pumping, lasting thirty-one days, was made in August and September, 1886, and showed a daily yield of 324,000 gallons at the start and 283,000 on completion. The level of the water in the test tubes located from fifty to one hundred feet from the pipe line, was lowered twenty to twenty-two feet in two hours, and returned to its normal level in less than twenty-four hours after the stopping of the pumps.

SINKING FUNDS No. 2.

By the Junior Editor.

In continuation of this subject, begun in the last number of the Journal, page 30, the following table is offered, which shows the amount accumulated by laying aside $1 at the beginning of each of n years and invested at different rates of interest.

This table was suggested by Hon. John E. Sanford of the Sinking Fund Commissioners of Taunton, Mass., and will perhaps be found to cover a larger number of cases as they actually arise, than will the table in the March number.

Table giving values for A when s = 1 in the formula.

$$A = \frac{s}{r}[(1+r)^{n+1}-(1+r)]$$

A = amount of fund at end of n years.
r = rate of interest received from investments.
n = number of years for contributions to sinking fund.
s = amount to be set aside at the beginning of each year.

Values of *n*	Values of *r*					
	3	*3½*	*4*	*4½*	*5*	*6*
10 years	11.80	12.13	12.48	12.84	13.21	13.97
20 "	27.65	29.27	30.95	32.78	34.72	38.99
30 "	48.96	53.62	58.33	63.75	69.76	83.80
40 "	77.33	87.49	98.79	111.84	126.83	162.38
50 "	116.09	135.58	158.70	186.53	219.80	307.76

This table can be applied in a given case as follows. The city of X issues a loan of $10,000 January 1, 1887, payable in 10 years, and proposes to pay it with a sinking fund made up of 11 contributions, the first Jan. 1, 1887 and the last Jan. 1, 1897, that is, one at the beginning of each year and one at the end of the last year. Each of the first ten contributions will be interest bearing, and for every dollar annually set aside, we shall have, by the table, assuming interest at 4 per cent., in 10 years, $12.48. Add to this a final payment of $1 bearing no interest, and we have $13.48 as the amount accumulated for each dollar annually invested. The city of X must accumulate, however, $10,000, and must therefore set aside each year 10,000 ÷ $13.48, or $741.68, including one payment at the end of the last year.

Suppose a sinking fund to be begun upon a certain capital already invested, then if

c = capital at beginning of time,
s = amount set aside at the end of each year,
n = number of years,
r = rate of interest from investments,
A = amount of Sinking Fund at end of n years,

A_1, A_2, A_3 = Amount of Sinking Fund at end of 1, 2, and 3 years respectively,

we shall have

$$A_1 = c + c\,r + s = c\,(1+r) + s$$
$$A_2 = c\,(1+r)^2 + s\,(1+r) + s$$
$$A_3 = c\,(1+r)^3 + s\,(1+r)^2 + s\,(1+r) + s$$

and

$$A = c\,(1+r)^n + s\,[\,(1+r)^{n-1} + \&c + (1+r)\,] + s$$

from which as on page 31 of March number we have

$$A = c\,(1+r)^n + \frac{s}{r}[\,(1+r)^n - (1+r)\,] + s \qquad (1)$$

and

$$A = (c + \frac{s}{r})\,(1+r)^n - \frac{s}{r} \qquad (2)$$

From (1), multiplying by r and solving with regard to s, we have

$$s = \frac{r(A - c\,(1+r)^n)}{(1+r)^n - 1} \qquad (3)$$

On page 31 of the March number, the brackets were omitted from equation (4). It should read,

$$A = \frac{s}{r}[(1+r)^{n+1} - (1+r)]$$

and in the table on page 30, when $n = 20$ and $r = 6$ per cent., A should be written \$25.64.

Comparative Financial Statement for 1886 from Reports adopting th

MAINTE

		Troy, N. Y.	Fall River, Mass.	Springfield, Mass.	New Bedford, Mass.	Holyoke, Mass.	Bay City, Mich.
RECEIPTS							
From Consumers.							
Rates domestic	A	42,891.67			40,113.24		14,927.19
" manufacturing	B	29,992.22	75,759.18	97,298.78	3,417 19	58,581.16	4,459.78
Net receipts	C	72,883 89			43,530.43		19,386.97
Miscellaneous	D	9,150.19	5,112.55	9,576.55	388.03		326.50
Total	E	82,034.08		106,875.33	43,918.46	6,974.27	19,713.47
From Public Funds.							
Hydrants	F			9,800.00		3,000.00	
Fountains	G						
Street Watering	H			1,870.00			
Public Buildings	I			2,215.97		309.00	
					79,700.00		
General Appropriations	J		56,000.00		12,000.00		30,160.00
Gross Receipts	K	82,034.08	136,871.73	120,761.31	135,618.46	68,864.43	49,873 47
EXPENDITURES.							
Management and Repairs,	A.A.	61,062.55	31,631.24	30,171.61	36,314.89	23,600.35	14,609.47
Interest on Bonds	B.B.	17,137.50	97,030.00	82,000.00	49,700.00	15,000.00	30,160.00
Total Maintenance	C.C.	10,862.50			86,014.89		
		78,200.05 shortage	128,661.24	112,171.61	30,000.00	38,600.35	44,769.47
Balance	D.D.	7,028.47	8,210.49	8,589.69	19,603.57	30,264.08	5,104.00
Total	E.E.	82,034.08	136,871.73	120,761.30	135,618.46	68,864 43	49,873.47

886 from Reports adopting the form suggested by the New England Water Works Association.

MAINTENANCE.

New Bedford, Mass.	Holyoke, Mass.	Bay City, Mich.	Taunton, Mass	Woonsocket, R. I.	Fitchburg, Mass.	Burlington, Vt.	New London, Ct.	Plymouth, Mass.	Waltham, Mass.	Sandusky, Ohio.	Trenton, N. J.
40,113.24	}	14,927.19	26,843.15	5,602.86	19,178.30	25,251.57	}	13,327.57	29,697.77		}
3,417.19	{ 58,581.16	4,459.78	6,607.72	1,229.46	5,193.06	2,061.95	{ 21,613.06	1,003.61	3,140.95		{ 64,725.76
43,530.43		19,386.97	33,349.87		24,371.36	27,313.52		14,331 18	32,838.72	16,448 71	
388.03		326.50	192.25	316.31		1,039.13		174.83	1,758.99	280.83	2,451.07
43,918.46	6,974.27	19,713.47	33,542.12			28,352.65	21,613.06	14,506.01	34,597.71	16,729.54	67,176.83
	3,000.00		8,944.00		11,750.00	1,200.00	6,500.00		3,480 00		301.66
			627.71		900 00	75 00	100.00		320.00		
			704.06		800.00	250.00	800.00				
	300.00		406.75		1,150.00	69.00	140.00		450.00		
{ 79,700.00											
{ 12,000.00		30,160.00			35,000.00						
135,618.46	68,864.43	49,873 47	44,224.64	7,248.63	73,971.36	29,946.65	29,153.06	14,506.01	38,847.71		67,478.49
36,314.89	23,600.35	14,609.47	13,729.31		42,179.06	11,274.13	4,528.19	5,936.91	9,056.15	11,848.89	13,569.54
49,700.00	15,000.00	30,160.00	23,114.67		26,612.50	12,642.00	17,500.00	4,270.00	21,659.06		15,850.00
86,014.89											
30,000.00	38,600.35	44,769.47	36,843.98		68,791.56	23,916.13	22,028.19	10,506 91	30,715.21		29,419.54
					{ 4,215.87				{ 7,756.00		
19,603.57	30.264.08	5,104.00	7,380.66		{ 963.93	6.030 52	7,124.87	3,999.10	{ 376.50		38,058 95
135,618.46	68,864 43	49,873.47	44,224.64		73,971.36	29,946.65	29,153.06	14,506.01	38,847.71		67,478.49

Comparative Financial Statement for 1886 from Reports adopting the form suggested by the New

CONSTRUCTION.

		Troy, N. Y.	Fall River, Mass.	Springfield, Mass.	New Bedford, Mass.	Holyoke, Mass.	Bay City, Mich.	Taunton, Mass.	Woonsocket, R. I.	Fitchburg, Mass.	
RECEIPTS.											
From Balance previous year	R	35,600.99		1,760.00	64,308.02	30,264.08	14,417.22	1,005.14			
" Bonds issued	S	27,734.20					18,000.00	27,000.00	300,000.00		
" Appropriation tax levy	T		23,000.00	12,000.00					3,122.39	7,500.00	
" other sources	U			986.96	3,607.87		5,104.00	3,808.31	11,371.01	6,856.00	
Total	V	63,335.19	23,000.00	14,747.15	67,915.89	30,264.08	37,521.22	31,813.45	314,493.40	14,356.29	
EXPENDITURES.											
Extension mains	F.F.	31,283.47	7,997.67	14,747.15	22,065.34	29,246.94	16,181.16	21,782.19	8,991.73	4,304.28	
" services	G.G.				5,628.48			6,651.28	9,853.01	8,579.85	
" special	H.H	8,128.39	14,997.01		14,116.26	1,017.14	20,555.05	1,190.14	295,642.66	1,449.35	
Total construction	I.I.	39,411.86	22,994.68		41,810.08			29,623.61			
Balances	J.J	23,923.33	5.32		26,105.81		785.01	2,189.84		22.81	
Total	K.K.	63,335.19	23,000.00	14,747.15	67,915.89	30,264.08	37,521.22	31,813.45	314,493.40	14,356.29	
Net cost of Works	W.	1,149,083.81	1,719,646.14	1,320,934.62	1,259,402.21	462,928.07	426,777.33	504,839.16	303,122.39	594,046.54	31
Bonded Debt	X.	443,500.00	1,700,000.00	1,200,000.00	820,000.00	250,000.00	377,000.00	478,700.00		485,000.00	23
Value of Sinking Fund	Y.	41,031.25	142,460.00	.....	.....	87,637.36	.....	153,163.22		132,870.02	9
Rate of Interest (per cent.)	Z.	4	5 7/10	6 2/10	5 8/10	.....	8	4, 4½, 6.		5 4/10	

*Amount issued since works began.

e form suggested by the New England Water Works Association.

UCTION.

Taunton, Mass.	Woonsocket, R. I.	Fitchburg, Mass.	Burlington, Vt.	New London, Ct.	Plymouth, Mass.	Waltham, Mass.	Sandusky, Ohio.	Trenton, N. J.
1,005.14				7,124.87	9,301.62	331.14	6,227.45	1,321.54
27,000.00	300,000.00					15,000.00		
	3,122.39	7,500.00	3,979.38				2,383.65	20,000.00
3,808.31	11,371.01	6,856.00	396.14		2,198.72	1,954.35	849.38	
31,813.45	314,493.40	14,356.29	4,375.52	7,124.87	11,500.34	17,285.49	9,460.48	21,321.54
21,782.19	8,991.73	4,304.28	3,003.48	4,156.66	5,164.97	15,156.91	5,516.71	15,580.32
6,651.28	9,853.01	8,579.85	1,372.04	1,153.98	847.64		2,255.00	
1,190.14	295,642.66	1,449.35		127.62	5,487.73			3,150.00
29,623.61				5,438.26				18,730.32
2,189.84		22.81		1,686.61		2,128.58	1,688.77	2,591.22
31,813.45	314,493.40	14,356.29	4,375.52	7,124.87	11,500.34	17,285.49	9,460.48	21,321.54
504,839.16	303,122.39	594,046.54	315,915.65	327,804.72		376,000.00	401,703.75	441,681.71
478,700.00		485,000.00	231,500.00	250,000.00	102,000.00	361,000.00	347,000.00	265,000.00
153,163.22		132,870.02	91,600.00			14,635.76	124,845.34	193,831.35
4, 4½, 6.		5 6/10	4 to 6	7	4 to 6	4. 6 6/10	7	5 to 6

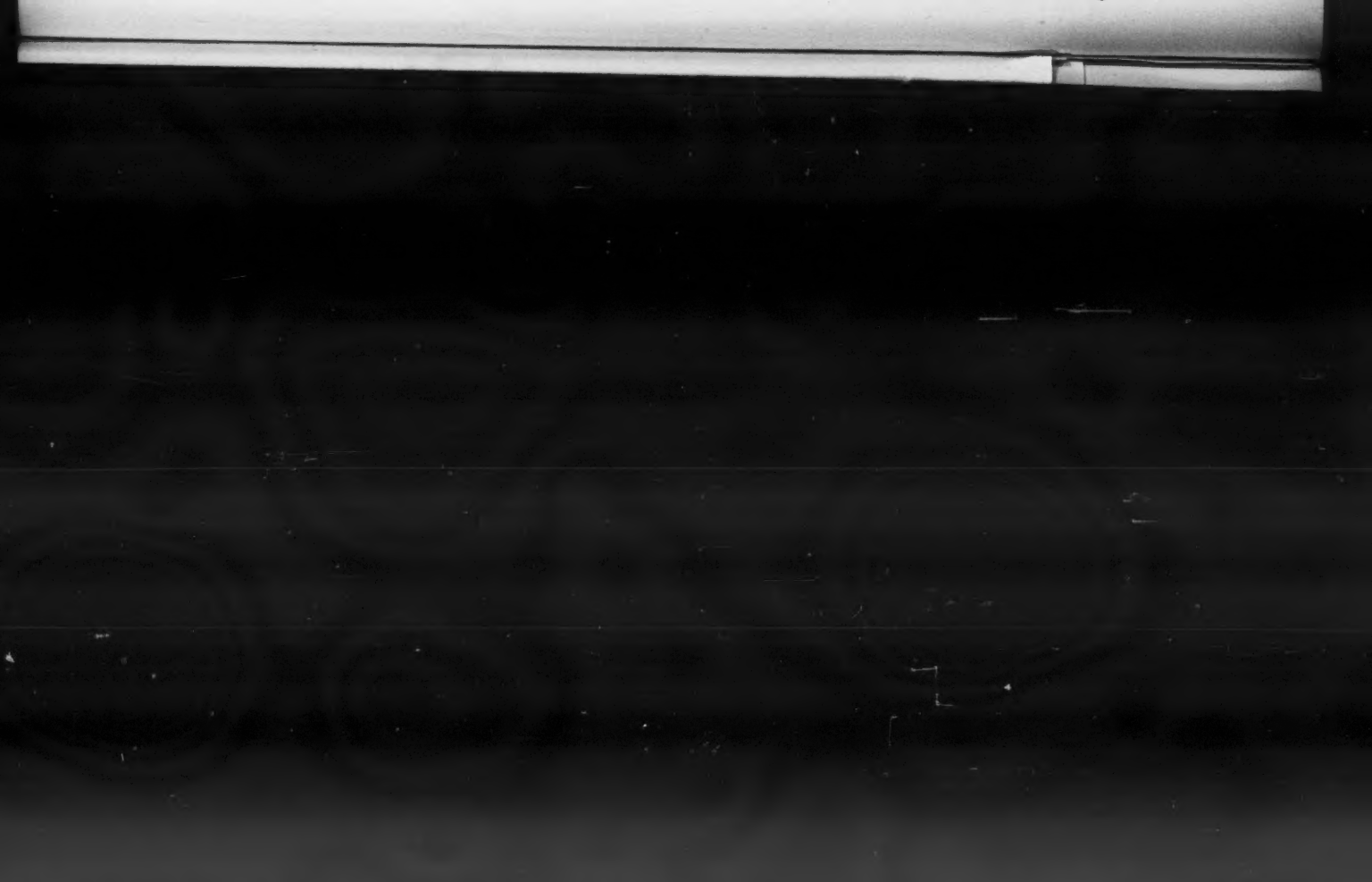
GENERAL STATISTICS.

	Population.	Date of Construction.	By whom owned.	Source of supply.	Mode of supply.	1 Builders of Pumping Machinery.	2 Description of coal used.
Boston, Mass.	451,898	1848 to 1864	City.	Lake Cochituate. Sudbury River. Mystic Lake.	Gravity 70 per ct. Pump 30 per ct.	H. R. Worthington. Boston Machine Co. H. R. Worthington.	Anthracite, Furnace, $4.93 to $5.08, 14 9/10 per ct. Bituminous, Broken, Clearfi $3.96 to $4.09, 8 8/10 per ct. a
Lowell, Mass.	64,051	1872	City.	Merrimac River.	Pump.	Morris. H. R. Worthington.	Cumberland, Maryland Co. $
Troy, N. Y.	60,000	1833 to 1886	City.	Artificial storage Reservoirs and Hudson River	Gravity and Pump.	Holly Mfg. Co.	Anthracite, Bituminous, Bro Pea, and Dust, $2.25 to $4.00, 15.5 per ct. a Wood $5.00.
Fall River, Mass.	59,026	1874	City.	Wattupa Lake.	Pump.	Boston Machine Co. H. R. Worthington. Davidson Co.	Cumberland, Georges Cre
New Bedford, Mass.	33,393	1869	City.	Acushnet River.	Pump.	Quintard Iron Wks[1] H. R. Worthington.[2] H. R. Worthington.[3] High Duty	Anthracite, Lehigh, $4.30 t 10 2/10 to 13 6/10 per cent ash Wood, $4.00.
Bay City, Mich.	29,415	1872	City.	Saginaw Bay.	Pump.	Holly Mfg. Co.	Pine Slabs and Edgings per cord, $1.00.
Taunton, Mass.	23,674	1876	City.	Ground water and Taunt'n River	Pump.	Holly Mfg. Co.	Anthracite, Egg, Packer Le Est. ash 13 per cent. $4.
Woonsocket, R. I.	19,000	1884		Croop Falls Brook.	Pump to Tank.	H. R. Worthington.	Bituminous, American Coal $4.90 delivered, 7.155 per ct. Wood, $3.00
Schenectady, N. Y.	13,365	1871	City.	Mohawk River.	Pump.	Dean Steam Co. and Holly Mfg. Co.	Anthracite, Delaware, Lackawana.
Burlington, Vt.	13,357	1867-8	City.	Lake Champlain.	Pump.	H. R. Worthington.	Anthracite, Grate Pittso 35 weeks, $3.85. Mill shav'gs, $30 per w'k, 1
Waltham, Mass.	15,500	1872-3	City.	Ground water	Pump.	H. R. Worthington.	Anthracite, Egg, Philadel and Reading, $4.96. 11 2/10 per cent ash.
Sandusky, Ohio.	15,838	1876	City.	Lake Erie.	Pump and Stand pipe.	H. R. Worthington.	Bituminous, Lump, Jacks $2.50. Ash 10 per cent
Plymouth, Mass.	7,230	1885	Town.	Ponds.	Gravity and Pumping.	H. R. Worthington.	Bituminous, $4.65.

From various Reports in Accordance with form Adopted by the New England Water Works Association.

PUMPING STATISTICS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Builders of Pumping Machinery.	Description of coal used.	Coal consumed for the year in pounds.	Lbs. of wood @	Total fuel consumed for the year.	Total pumpage for the year in gallons.	Average static hd. against which pumps work.	Av'ge dynamic hd. against which pumps work.	Number of gals. pumped per pound of coal.	Duty in foot pounds per 100 pounds of coal, no deductions.	Cost per million gallons into reservoir, figured in pumping expenses.	Cost per million gallons one foot high, figured on pumping expenses.	Cost per million gallons into reservoir, figured on total maintenance.	Cost per million gallons one foot high, figured on total maintenance.
orthington. Machine Co.	Anthracite, Furnace. $4.93 to $5.08, $14\frac{2}{10}$ per ct. ash.			1,981,200	1,065,221,000		111.65	537.7	50,065,200	$8.52	$0.0763		
orthington.	Bituminous, Broken, Clearfield, $3.96 to $4.09, $8\frac{6}{10}$ per ct. ash.			5,869,500	2,700,676,300		148.82	460.1	57,108.200	$8.01	$0.0538		
orris. orthington.	Cumberland, Maryland Co. $4.65.			2,214,550	1,222,150,080		164.08	558.	75,465,444	$6.52	0.0397		
				508,000	219,472,560		165.68	430.	59,654,078	$7.53	0.0455		
Mfg. Co.	Anthracite, Bituminous, Broken Pea, and Dust, $2.25 to $4.00, 15.5 per ct. ash. Wood $5.00	Anth. 4,556,160 Bitum. 1,445,233	7343	6,008,736	1,630,500,310	231.	242.	280.	54,800,010	$16.09	106.96	$35.65	.....
Machine Co. orthington. dson Co.	Cumberland, Georges Creek.				585,270,956		185.73	282.1		$18.10		$207.20	
d Iron Wks[1] orthington.[2] orthington.[3] h Duty	Anthracite, Lehigh, $4.30 to $5, $10\frac{3}{10}$ to $13\frac{6}{10}$ per cent ash. Wood, $4.00.	[1] 541,320 [2] 1,116,700 [3] 479,893	1673 3854 1800	542,993 1,120,554 481,693	260,299,173 438,707,088 505,559,506	124.9 124.4 125.9	130.9 126.1 128.	481. 392. 636.	52,334,039 41,173,994 67,717,588	$17.21	0.13457	$79.15	0.61882
Mfg. Co.	Pine Slabs and Edgings, per cord, $1.00.			2.216,500	779,761,852		108.5	352.	31,833,914	$9.54	0.0879	.....	.....
Mfg. Co.	Anthracite, Egg, Packer Lehigh, Est. ash 13 per cent. $4.70.	700,600			282,339,158		151.62	356.	45,174,265	$20.02	.132	$130.51	.86
Worthington.	Bituminous, American Coal Co's, $4.90 delivered, 7.155 per ct. ash. Wood, $3.00	313,168	27.739	340,907	53,884,669	235.16	240.63	158.	31,721,531	$30.01	0.124	$351.37	$1.46
Steam Co. and Mfg. Co.	Anthracite, Delaware, Lackawana.	1,920,220	4.780	1,925,000	405,008,270	175.	187.	211.	32,712,040	$19.50	.10428	$	$ .143
Worthington.	Anthracite, Grate Pittson, 35 weeks, $3.85. Mill shav'gs, $30 per w'k, 17wks				226,961.525	289.	316.			$21.08	$0.0667	$105.38	$ .333
Worthington.	Anthracite, Egg, Philadelphia and Reading, $4.96. $11\frac{5}{10}$ per cent ash.	741,800		741,800	221,787,505	164.		300.		$17.77		138.48	
Worthington.	Bituminous, Lump, Jackson, $2.50. Ash 10 per cent.			3,030,800	637,691,000		145.	210.	27,900,769	$9.42	$0.059		
Worthington.	Bituminous, $4.65.	491,895	400	492,225	214,477,051	35.	100.	435.	36,350,339	11.89	0.1189	48.98	$0.4898



Comparative Statement of the CONSUMPTION in various places, for the year 1886, compiled from reports prepared in accordance with form adopted by the N. E. Water Works Association.

NAME OF PLACE.	*1* Estimated total population at date.	*2* Estimated population on line of pipe.	*3* Estimated population supplied at date.	*4* Total number gallons consumed for the year.	*5* Passed through domestic meters.	*6* Passed through manufing meters.	*7* Average daily consumption in gals.	*8* Gallons per day to each inhabitant,	*9* Gallons per day to each consumer.	*10* Gallons per day to each tap.
Boston [Cochituate]	358,000		350,000	9,719,173,400	310,687,500	2,015,520,000	26,627.900	74.3	76.1	498
" [Mystic]	102,000		100,000	2,700,937,400	14,329,750	393,596,300	7,399,800	72.5	74.	459
Lowell, Mass.	67,000		65,000	1,441,622,640	326,999,950		3,949,651	59.	61.	554
Troy, N. Y.	60,000			3,000,000,000	44,688,000		8,000,000	133.		
Fall River, Mass.	59,026		50,900	585,270,956			1,603,482	27.1	31.8	403
Springfield, Mass.	39,000	33,750	29,000	1,368,750,000	78,878.410		3,750,000	96.	129.	829
New Bedford, Mass.	34,500	30,251	28,480	1,086,534,615	2,055,733	105,858,655	2,976,807	86.	104.	569
Holyoke, Mass.	31,348	30,848	30,640	816,402,800	152,955.240		2,236,720	71.3	73.	1097
Bay City, Mich	32,000	15,000	10,000	779,761,852	30,981,127	46,053,194	2,136,334	66.	213.	1675
Taunton, Mass.	23,674	21,000	18,000	282,3 9,158	27,126,817	67,979,875	773,531	32.	43.	283
Woonsocket, R. I.	19,000	16,000	5,990	53,884,669	12,346,144	6,435,487	147,629	9.2	24.6	339
Fitchburg, Mass.	16,000	14,000	11,800	365,000,000	13,014.000	62,000,000	1,000,000	63.	84.	500
Burlington, Vt.	13,500	13,200	12,900	226,961,525	21,131,690	9,496,570	621,812	46.6	48.2	277
New London, Conn.	12,000	11,000	8,979	300,000,000			822,000	68.5	91.5	495
Plymouth, Mass.	7,400	6,200	6,100	214,477,051			589,822	80.	97.	459
Ware, Mass.	6,200	5,000	600				40,000	6.5	61.	625
Waltham, Mass.	15,500	14,000	13,000	221,787,505	13,565,107		607,737	39.2	46.7	322
Sandusky, Ohio.	23,000	16,000	11,000	637,691,000	6,669,892	39,849,897	1,747,000	76.	159.	1131

DISTRIBUTION

Statistics relating to MAIN PIPE work in various places for the year 1886 compiled from reports prepared in accordance with form adopted by the New England Water Works Association.

NAME OF PLACE.	1 Kind of pipe used.	2 Size of Distribution pipe in inches.	3 Distribution pipe extended during 1886.	4 Distribution pipe discontinued during 1886.	5 Total length of distribut'n pipe above 4 inch in miles.	6 Cost of repairs per mile.	7 Number of leaks during 1886.	8 Total length of distribution pipe less than 4 in. in miles.	9 Hydrants added during 1886.	10 Number of hydrants now in use.	11 Stop gates added now in use.	12 Number of stop gates now in use above 4 inch.	13 Number of stop gates less than 4 inch.	14 Number of blow off gates.	15 Range of pressure at center for day and night in lbs.
Boston, [Cochituate]	Cast Iron.	48 to 4	14.1 miles.		414.2				125	4806	205	4418			
" [Mystic]	Cast Iron W. I. C. L.	30 to 3	2. "		133.2			6.2	37	818	33	1236			
Lowell, Mass.	Cast Iron.	30 to 4	10,103 "		81.3		12		13	773	7	538		17	50 to 60
Troy, N. Y.	Cast Iron.	30 to 4	9,772 ft.	1,350 ft.	50.19				30	546	81	809		11	25 to 115
Fall River, Mass.	Cast Iron.	24 to 6	none.		58.8			.74	7	606	10	612			80
Springfield, Mass.	Cast Iron. Cement Lined.	30 to 3	24,844 "	5,640 "	76.6				33	490	42	696	176	70	30 to 120
New Bedford, Mass.	Cast Iron W. I. C. L.	30 to 4	11,448 "	1,940 "	52.06	$10.63	8	1.1	21	388	33	509	57	51	25 to 36
Holyoke, Mass.	Wt. and Cast Iron.	20 to ½	17.436 "		40.5	3.13	3	5.3	15	262	26	266		12	45 to 100
Bay City. Mich.	Cast Iron Wyckoff.	20 to 3	13,514 "	421. "	24.75	5.85	1		20	180	36	348	3	19	
Taunton, Mass.	Cast Iron.	20 to 4	23,074 "		52.9	32.15	6	.77	35	457	40	318	6	20	45 to 50
Woonsocket, R. I.	Cast Iron.	14 to 4	11,296 "		18.2	14.19 cement.			32	270	41	204	1	13	60 to 125
Fitchburg, Mass.	C. I. and C. L.	16 to 4	7,355 "		33.5	179.92	60	1.6	10	245	22	169	16	7	78 to 160
Burlington, Vt	C. I. and C. L.	10 to ½	5,257 "	3,454 "	29.4	38.00		5.2	1	163	6	257	67	4	70 to 85
New London, Conn.	C. I. and C L.	16 to 4	4,135 "		24.9	29.21		1.8	3	130	4	118		16	34 to 53
Plymouth, Mass.	Cement Lined.	20 to 2	10,486 "		23.50	10.00		7.67	1	75	17	182	89	15	
Ware, Mass.	Cast Iron.	12 to 4			6.50					49		64		3	85
Waltham, Mass.	C. I. & W. I. C. L.	16 to 2	8,169 "		32.67	15.06			6	178	32				55
Sankusky, Ohio.	Cast Iron.	20 to 3	9,293 "		23.7	17.50	1	1.	10	161	6	155	5	7	35 to 70

DISTRIBUTION.

Statistics relating to SERVICE PIPE work in various places for the year 1886, compiled from reports prepared in accordance with form adopted by the New England Water Works Association.

NAME OF PLACE.	16 Kind of pipe used.	17 Size of service pipe in inches.	18 Length of service pipe extended.	19 Length of service pipe discontinued.	20 Total length of service pipe now in use in miles.	21 Taps added during 1886.	22 Number of taps now in use.	23 Average length of service.	24 Average cost of service.	25 Meters added during 1886.	26a Domestic meters now in use.	26b Manufacturing meters now in use.	27 Motors and elevators added during 1886.	28 No. of motors and elevators now in use.
Boston [Cochituate]	Lead.	¾ to 2	45,867			1590	53,400				3415			348
" [Mystic]	Lead, W. I. Cem't.	¾ to 2	18,536			182	16,110				469			0
Lowell, Mass.	Lead, Wt. Iron.	¾ to 3	8,527		52.2	241	7,127			40	1461			
Troy, N. Y.	Lead, Cast Iron.	¾ to 6				221				4	35		1	11
Fall River, Mass.	Lead.	¾ to 2				168	3,986			156	2725			6
Springfield, Mass.		¾ to 4				282	4,519			64	349		8	98
New Bedford, Mass.	Lead, Cast Iron.	¾ to 8	8,883		30.	260	5,225	34.2	17.92	15	45	37	1	26
Holyoke, Mass.	Cem't, Rubber, C.I.	¾ to 4	2,380		7.7	119	2,038	20.	11.94	4	140		18	51
Bay City, Mich.	L., Iron, Wyckoff,	¾ to 8				38	1,276			20	174		1	2
Taunton, Mass.	Cement.	¾ to 1¼	11,193		26.2	226	2,727	49.6	19.06	83	623	57	2	5
Woonsocket, R. I.	Lead.	¾ to 1¼	3,715	69.	1.3	233	425	15.5	10.34	296	342	22		
Fitchburg, Mass.	Wt. Iron Cement.	¾ to 6	11,722		24.9	174	1,999	67.5	18.24	96	394	57	3	17
Burlington, Vt.	Lead, Iron Galv'd.	¾ to 4	3,390	180.	12.48	104	2,243	32.7	13.19	23	227	35	1	6
New London, Ct.	W. I. Galvanized.	¾ to 4	1,520	164.	5.8	81	1,659	18.3	13.46	8	36		3	11
Plymouth, Mass.	Lead, Cement.	¾ to 1	840		5.	42	1,284	20.	4.89	1			1	2
Ware, Mass.	Iron, Cement L.	¾ to 2			.33	77		24.2	7.29		9			1
Waltham, Mass.	Wt. Iron Cement.	¾ to 6	6073.8	183.7	21.00	128	1,884	45.9	12.42	4	20		1	4
Sandusky, Ohio.	Cast, Wt.I., Lead.	¾ to 6				47	1,544	30.2	12.45	28	25	27	4	36

B/4